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TERRESTRIAL ORGANISMS SURVIVE IN SIMULATED JUPITER ATMOSPHERE

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TERRESTRIAL ORGANISMS SURVIVE IN SIMULATED JUPITER ATMOSPHERE

Egmont Koch

ABSTRACT. It is pointed out that the present reducing atmosphere of the giant planets is very similar to the terrestrial atmosphere at the time of the origin of life on Earth. Bacteria which use methane as a source for carbon are discussed, and the chemical reactions involved are examined. Investigations regarding an adaptation of various microorganisms to a methane-ammonia-hydrogen atmosphere are considered including tests in which plants such as the Euphorbia xylophyloides, Euphorbia hermentiana, and Euphorbia cladestina were kept for two months in such an atmosphere. It was found that many microorganisms in the plants had survived the imposed conditions and had even multiplied. Studies with a one-celled alga and with the aquatic plant Elodea are also discussed.

ADAPTATION EXPERIMENTS IN SPACE BIOLOGY /72*

The study of organisms in changed surrounding conditions represents one of the most important methods of investigating the possibility of extra-terrestrial life on neighboring planets within our solar system. Thus it is possible to change pressure, temperature, atmospheric composition, force of gravity, diurnal and nocturnal rhythm as well as radiation dose from the normal conditions on the Earth. It thus becomes possible to test the capacity of the organisms to adjust. It has been possible to repeatedly show that many terrestrial forms of life can exist under very extreme conditions. In the area of exobiology, such studies have been especially carried out for microorganisms in a simulated Mars atmosphere.

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*Numbers in the margin indicate pagination in the original foreign text.

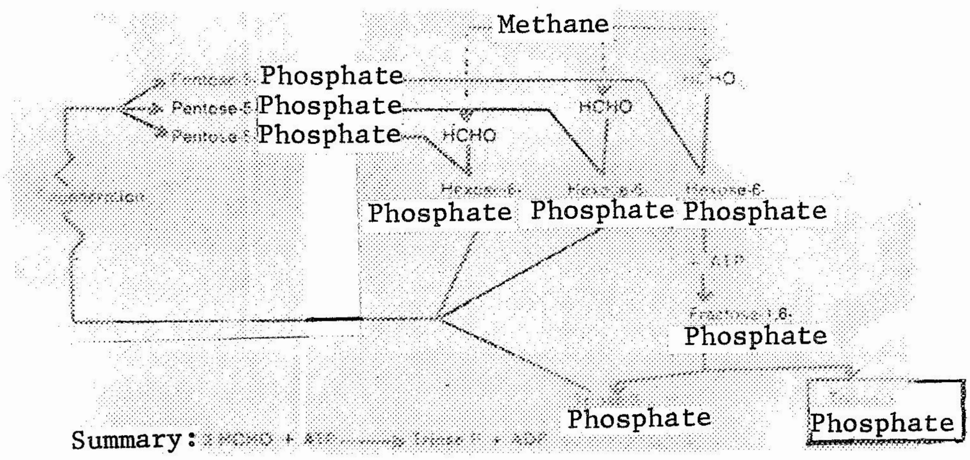
Since it has become known that the temperature of the giant planet Jupiter increases toward the center, researchers have been concerned with the chances that various organisms will survive in a model Jupiter atmosphere. Since the present atmosphere of this giant planet apparently does not differ from the atmosphere which existed during the formation of our planet's life, several researchers believe that extraterrestrial life may be even more probable on Jupiter than on Mars.

In contrast to the atmospheres of the inner planets which have an oxidizing effect today, the atmospheres of Jupiter and the other giant planets have a reducing character and have an excess of hydrogen and helium. For this reason, investigations are carried out on the capacity to survive atmospheres consisting of hydrogen, helium, ammonia, methane and water. These investigations are being carried out for the oldest terrestrial organisms, which lived in the reduced primordial atmosphere 2 - 3 billion years ago. The change from the terrestrial primordial atmosphere into an oxidizing carbon dioxide atmosphere took place about 1.6 billion years ago. This is because older rock formations have low element-oxidization stages, which could only be produced without the presence of oxygen.

The bacteria are one of the oldest and therefore the most primitive forms of life on the Earth. In fact, several of them still today can exist in a reducing atmosphere and do survive in a simulated Jupiter atmosphere. But also higher organisms, for example green plants which require light to live, can sometimes stand the extreme environmental conditions of the Jupiter atmosphere. Some of them can even produce an inverse methane assimilation.

METHANE CONSUMING BACTERIA

Bacteria which use methane as the carbon source were first described by Sohngen, 1906. At the present time two types of these methane processing microorganisms are known:



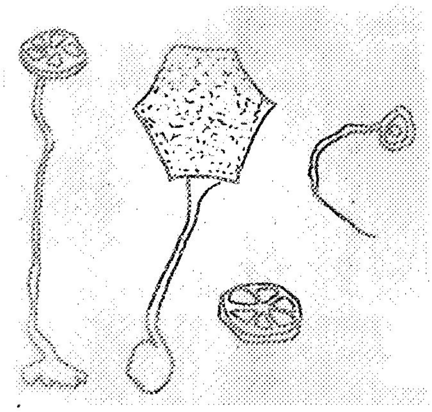
Possible insulation method of methane in Pseudomonas methanica (according to Kemp and Quayle, 1965).

1. Pseudomonas methanica

2. Methanomonas methanooxidans

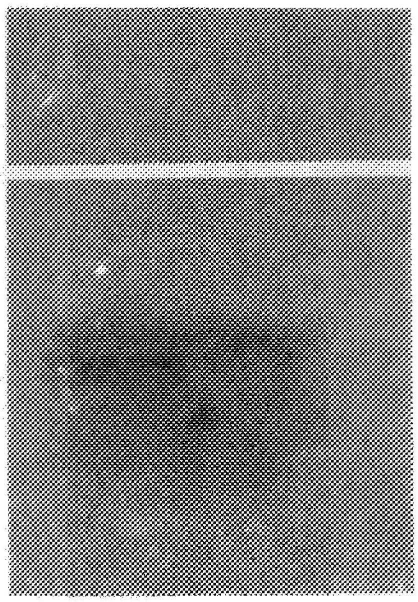
Studies of the oxidation of the C-1 building block methane or methanol have been carried out for both types. In the case of the pseudomonas methanica, the synthesis of the cell material has been explained with C^{14} methane and C^{14} methanol. When radioactive C-1 building blocks are installed, 90% of the radioactivity first occurs in the phosphorized compounds, where 70 - 90% occur in glucose phosphate and fructose phosphate. However, phosphoric glyceric acid only amounts to 2 - 17%.

The oxidation of the methane to formaldehyde should be the first reaction step. According to Kemp and Quayle there is a condensation of formaldehyde with ribose-5-phosphate to form allulose phosphate. This is followed by transformation into fructose-6-phosphate (this accounts for the high radioactivity). Both authors then propose a pentose-phosphate cycle (see Figure) in which the synthesis of triose-3-phosphate results in three molecules of



Top: Drawing of several microorganisms which survived in methane-ammonia atmosphere with enlargement by a factor of 1000 (according to Siegel and Giumarro, 1965).

Bottom: Photographs of these microorganisms.



formaldehyde and one molecule of ATP.

The explanation of this installation mechanism of methane into Pseudomonas methanica shows clearly that this bacteria can use methane or methanol as the carbon source in an oxidizing carbon dioxide atmosphere, 1.6 billion years after the reducing methane atmosphere.

MICROORGANISMS SURVIVED IN A METHANE-AMMONIA MEDIUM

The researchers Siegel and Giumarro carried out experiments for the adjustment of various microorganisms to a methane-ammonia-hydrogen atmosphere. Thus the researchers, for example, held healthy plants such as Euphorbia xylophyloides, Euphorbia hermentiana and Euphorbia cladestina for two months at one atmospheric pressure and 22 - 24° Celius in a $CH_4NH_3H_2$ atmosphere. After the experiments were over, an amount of microorganisms were found on the plants. These had survived and had reproduced. The biologists found gram negative as well as gram positive bacteria and many microorganisms for which no identification was possible.

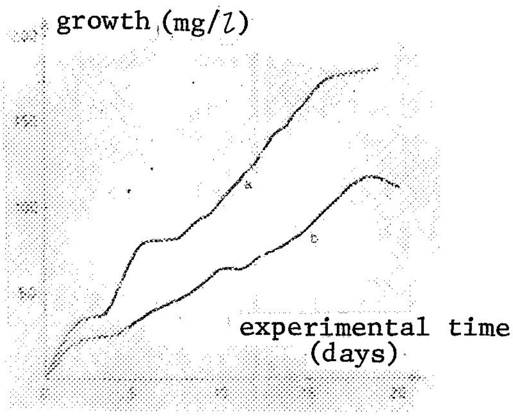
SEVERAL MICROORGANISMS ISOLATED FROM XEROPHYTES (ACCORDING TO SIEGEL AND GUIMARRO, 1964).

Xerophyte	Atmosphere	Microflora after Two Months
Euphorbia xylophylloides	5 % NH_3, 45 % H_2, 50 % CH_4	Motile bacilli, length 1-2 μ Non-motile bacilli, length 2-6 μ Cocci, diplococci, diameter 1-2 μ
	15 % NH_3, 25 % H_2, 50 % CH_4	Yeastlike forms Non-motile bacilli 1x6 μ Red bacilli 1x3 μ
Euphorbia clandestina	5 % NH_3, 45 % H_2, 50 % CH_4	Irregular, raised, opalescent to pale yellow colonies (diameter 1-3 cm)
		Consisting of monococcoid cells Motile bacilloid forms 1x6 μ and 1x3 μ

Microorganisms were also investigated which the microbiologist Barghoorn found in fossil impressions in 2 - 3 billion year old rock formations. Even today these are quite abundant. Since this microlife already lived in the primordial Earth atmosphere, it is not surprising that it could exist in the simulated Jupiter atmosphere.

GREEN PLANTS ALSO SURVIVED

The Swedish biochemist L. Enebo was the first to be able to show that a green plant, a one-cell chlorella-green algae, can survive in a Jupiter-like methane atmosphere. As this researcher found, the algae thrives better in pure methane than in normal air. The fact that at the end of the experiment, 6% oxygen was found in the initially pure methane atmosphere, was attributed by L. Enebo to the light-induced photolysis of the water by the green plant. The installation of the methane certainly occurred via the oxidation of the carbon monoxide using this oxygen. Even though the results cannot be reproduced



Growth of a chlorella algae culture in methane (a) and in normal atmosphere containing CO_2 (b) according to Enebo, 1967.

with radioactive C^{14} methane, the results of the Swedish biochemist are nevertheless extremely interesting regarding the question of Jovian life.

It was possible for the author of this report to recently show that a higher developed green plant can survive in a Jupiter-like methane atmosphere. Apparently the investigated water plant Elodea (water weed) even has the capacity of inverse methane assimilation. The following results obtained with radioactive C^{14} methane support this conclusion:

1. The carbon of the Elodea plant from light vessels is radioactive: the dissolution of the methane in the cell fluid cannot be looked upon as the only cause of radioactivity in the uncarbonized plant parts.

2. The regions of increased cell division can be recognized as regions of increased radioactivity based on the autoradiograms.

3. The radioactivity intensity depends on the illumination intensity to which the plant was subjected. There is no detectable radioactivity in plants taken from dark vessels.

We doubt that there was any activity of methane-oxidizing bacteria, which produced carbon dioxide in the experimental vessel, because the long wave ultraviolet radiation used in the investigations probably also brought about inactivation of the microorganisms.

The first autoradiographic-chemical analyses showed that only relative few compounds are marked. Therefore, we do *not* believe *that it is possible* to have either C^{14} carbon dioxide assimilation or activity of methane-oxidizing bacteria. /73

The marking of the carbohydrate saccharose in connection with the second result of the autoradiographic investigations is especially interesting. Since the saccharose represents the form of transportation of the carbohydrate and because it wanders from the chloroplasts into the region of increased chemical activity, it appears possible that the relatively high radioactivity in plant shoots can possibly be attributed to the accumulation of saccharose carbon.

These analyses support the assumption of a light induced installation of C^{14} carbon from methane.

The organisms described support the existence of Jovian life. Apparently the Jupiter atmosphere consists of a large reservoir of important organic and pre-biological material, so that the creation of life is therefore a definite possibility.

The chemical analyses were carried out by Professor Metzner and collaborators at the Institute of Chemical Plant Physiology in Tubingen.

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